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Interim Report

Survey and Analysis of Environmental Requirements for Shipboard Electronic Equipment Applications

Volume I

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Prepared by:

SYNETICS Corporation
810 Jamacha Road, Suite 206
El Cajon, CA 92019-3205

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Ed Newman Naval Sea Systems Command
SEA-06KR1
Washington, DC 20362-5101
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SURVEY AND ANALYSIS OF ENVIRONMENTAL REQUIREMENTS FOR SHIPBOARD ELECTRONIC EQUIPMENT APPLICATIONS

1.0 INTRODUCTION

1.1 Purpose

This interim report presents the results of a survey and related investigations to ascertain the environmental requirements typically specified for Naval Shipboard applications and to compare these requirements with available VMEbus ruggedized and MIL SPEC components in order to characterize the efforts required to upgrade VMEbus components for Navy Standard Backplane use.

1.2 Background

Applications for the Navy Standard Backplane will involve environments which are more stressful than the office environment for which most commercial products are designed. Fortunately, some effort has already gone into the ruggedization and/or militarization of components for VMEbus. The VMEbus can effectively be used as a baseline for survey and analysis of environmental requirements that are met by manufacturers of existing VMEbus components. A current market survey of these special application products, and an objective, unbiased analysis of the environmental specifications to which the products were designed and tested was performed in order to determine what Navy-funded efforts will be required in order to develop Navy Standard Backplane components to various levels of ruggedization and militarization.

1.3 Scope

The product information presented in this report results from responses by industry to a request for information concerning ruggedized and militarized VMEbus components. Product information on commercial off-the-shelf (COTS) components was derived partially from responses by industry and partially from the VFEA International Trade Association (VITA) VME-VXI-Futurebus+ Compatible Products Directory.

Environmental requirements were extracted from draft Military Standard-General Requirements for Electronic Equipment Specifications, MIL-STD-2036 (Navy), dated 13 June 1991. The scope of these investigations was limited to examination of the environmental conditions listed in paragraph 5.1.2 of MIL-STD-2036 (Navy), and further limited by the assumption that the VMEbus components under consideration would be installed in a sheltered, controlled environment.

1.4 Approach

In order to collect product information from industry, a letter requesting pertinent information was mailed to marketing and technical representatives from 224

manufacturers of VMEbus components listed in the VITA Compatible Products Directory. Responses to the request for information were reviewed, categorized, and appropriate information was entered into a dBASE III database for analysis.

Draft MIL-STD-2036 (Navy) of 13 June 1991 was used as a basis for determining environmental requirements for shipboard equipments. A specification tree analysis was performed to trace the draft MIL-STD-2036 (Navy) requirements to the source documents in order to determine the specific numeric and test requirements.

Using the numeric requirements from the specification tree analysis, a series of "queries" were made into the VMEbus component database in order to determine which, if any, components met the various requirements. The dBASE III query capability offers the opportunity to state multiple conditions, therefore it was possible to identify those components that met multiple environmental conditions (e.g., temperature and humidity and sinusoidal and random vibration).

From the full set of environmental requirements, a subset was selected which appears to be a reasonable target for the Navy Standard Backplane. The intent was to achieve a reasonable compromise between excessive cost to design and test equipment for extreme environments and insufficient ruggedization for Navy use.

Comparison of the subset of environmental requirements to the environmental capabilities of available VMEbus components as well as an analysis of the requirements themselves facilitated identification of the areas in which additional effort in specification, design, and testing of components will be needed. This comparison and analysis focused primarily on the requirements for minimal acceptance for shipboard use, and also considered the specifications that are used by industry in ruggedizing backplane bus components.

2.0 SURVEY OF VMEBUS COMPONENTS

2.1 Request for Information

The industrial/commercial availability of ruggedized/militarized boards, enclosures, and power supplies for the open architecture VMEbus standard backplane was determined by means of a survey of VMEbus component manufacturers. A letter, shown in Figure 1, requesting pertinent information on VMEbus components was mailed to marketing and technical representatives from 224 manufacturers of VMEbus components listed in the VITA Compatible Products Directory. The responses to this request for information were reviewed and categorized, and appropriate information was entered into a dBASE III database for analysis.

The response to our request for information was not considered fully representative of the availability of VMEbus products; i.e., less than half of the manufacturers contacted responded with information on their products. In order to supplement the database, particularly in the area of commercial off-the-shelf (COTS) products, information was extracted from the VITA VME-VXI-Futurebus+ Compatible Products Directory and added to the database.

2.2 VMEbus Product Database

The structure of the dBASE III database, given in Table 1, was established to reflect the environmental characteristics typically specified by manufacturers. Included in the database were fields to indicate the type of component (see Table 2), category (Militarized-MIL, Ruggedized-RUG, or Commercial-off-the-shelf-COM), features of the board or component that distinguish it from other boards and components, and comments regarding the component's environmental characteristics. In the database, Militarized (MIL) and Ruggedized (RUG) categories represent the manufacturer's characterization of the product. The contents of the database are summarized in Appendix A-1, and the complete contents of the database are provided as Appendix B. To supplement the VMEbus product database, a separate database was created which provides information on the vendors themselves. This database contains the vendor name, address, phone, and fax numbers;identifies whether the supplier is a vendor or distributor; and, identifies marketing and technical points of contact. The contents of this database are provided in Appendix A-2.

SYN-RHS-891012
October 12, 1989

Dear Sir:

This letter requests information concerning your company's VMEbus components. Under contract to the U.S. Navy and in conjunction with the Next Generation Computer Resources (NGCR) Project Office, *SYNETICS* Corporation has been tasked to procure, integrate, programs, test and benchmark a state-of-the-art high performance multiprocessor computer using a standard backplane. For this task the VMEbus has been selected as the backplane to test. In order to select a specific VMEbus components vendor, *SYNETICS* needs to determine the industrial/commercial availability of ruggedized/militarized boards, enclosures and power supplies for the open-architecture VMEbus IEEE standard backplane.

Accordingly, it is requested that *SYNETICS* be provided at your earliest convenience with the below information as available:

1. Identity and description of VMEbus hardware your company markets.

2. Identity and description of the ruggedized or MIL-SPEC VMEbus hardware your company markets (e.g., cards, power supplies, cages, etc.) including:

   A. The design/environmental specification/standards to which the hardware was designed.

   B. How the hardware design was ruggedized (e.g., parts replacement, repackaging, etc.).

   C. The specification/standards to which the hardware was tested.

   D. Reliability, maintainability and quality assurance mechanisms used in hardware production.

   E. Copies of hardware test laboratory reports.

   F. Whether and by what independent company (such as VMElaboratories) the hardware has been certified as conformant to the VMEbus specification.

3. Price list for both the hardware and the software (e.g. operating system, compilers, utilities, screen editor, ROM's, maintenance, etc.)

Point of contact at *SYNETICS* is Mr. Rusty Scheerer or Mr. Dan Gold at (619)442-3703.

Thank You,

Mr. R.H. Scheerer
Member of the Staff

Figure 1 - Request for Information on VMEbus Products

Table 1 - Structure of The VMEbus Product Database

FIELD	FIELD NAME	TYPE	WIDTH
1	Supplier	Character	30
2	Product	Character	35
3	Part Number	Character	15
4	Type	Character	3
5	Category	Character	3
6	Feature 1	Character	50
7	Feature 2	Character	50
8	Feature 3	Character	50
9	Feature 4	Character	50
10	Feature 5	Character	50
11	Feature 6	Character	50
12	Feature 7	Character	50
13	Feature 8	Character	50
14	Feature 9	Character	50
15	Feature 10	Character	50
16	Feature 11	Character	50
17	Feature 12	Character	50
18	MIL-STD-461	Character	1
19	MIL-STD-704	Character	1
20	MIL-STD-810	Character	1
21	MIL-STD-883	Character	1
22	MIL-STD-1397	Character	1
23	MIL-STD-1553	Character	1
24	MIL-STD-1750	Character	1
25	MIL-E-4158	Character	1
26	MIL-T-5400	Character	1
27	MIL-E-16400	Character	1
28	Operating Temperature	Character	25
29	Non-Operating Temperature	Character	25
30	Humidity	Character	25
31	Vibration-Sine	Character	25
32	Vibration-Random	Character	25

Table 1 (continued)

FIELD	FIELD NAME	TYPE	WIDTH
33	Shock	Character	30
34	Altitude	Character	25
35	Comment 1	Character	50
36	Comment 2	Character	50
37	Comment 3	Character	50
38	Comment 4	Character	50
39	Comment 5	Character	50

Table 2 - VMEbus Component Types

COMPONENT TYPE	ABBREVIATION
Single Board Computer	SBC
Input/Output	I/O
Memory	MEM
Mass Storage	MAS
Power Supply	PWR
Chassis	CHA
Local Area Network	LAN
Chip Set	CHS
Digital Signal Processor	DSP
Video/Graphics	VGR

3.0 SPECIFICATION TREE ANALYSIS

Initially, the specification tree analysis was based on specifications for shipboard, submarine, airborne, fixed (ground), and shore based equipments and analyzing the different environmental requirements for these equipments by tracing the requirements through one or more environmental standards or specifications called out in the equipment specification to the specific required numerical value. Twenty-one (21) equipment specifications were obtained and examined to develop a composite list of specifications and standards referenced in the equipment specifications.

The emergence of draft MIL-STD-2036 (Navy) General Requirements for Electronic Equipment Specifications, resulted in a redirection of specification tree analysis efforts. Instead of using equipment specifications as a basis for analysis, the evolving draft MIL-STD-2036 (Navy) became the basis for identification of environmental requirements.

3.1 Determination of Environmental Requirements

In some cases, specific environmental requirements are stated directly in draft MIL-STD-2036 (Navy); however, in most cases, reference is made to another standard or specification. These standards and specifications were obtained and reviewed in order to trace the specification tree to the specific environmental requirement.

3.1.1 Environmental Requirements for Militarized Components

The environmental requirements for militarized, or fully hardened, components are summarized in Table 3. Note that some requirements are shown as "Not Applicable" due to the assumption that the VMEbus components under consideration would be installed in a sheltered, controlled environment. Other requirements are shown as "Not Investigated" due to the nature of the requirement and the probability that the VMEbus components would not be subjected to the particular environmental conditions.

Table 3 - Environmental Requirements for Militarized Equipment

PARAGRAPH	REQUIREMENT	MILITARIZED (Fully Hardened) SPEC/STD	MILITARIZED (Fully Hardened) REQUIRED VALUE
5.1.2.1	Altitude, Non-Operating	MIL-STD-810, Method 500 -or- IEC 68-2-13	15,000 Ft Un-Pressurized
5.1.2.2	DC Magnetic Field Environment	DoD-STD-1399, SEC 070, Part 1	Normal:1600 Amp/m(5 min) (Steady State Field) Special Conditions:400 Amp/m (Residual Field)
5.1.2.3	Electronic Susceptability	MIL-STD-461(Requirements) MIL-STD-462(Tests)	RS01 CS01 RS02 CS02 RS03 CS06
5.1.2.4	Dust And Sand	MIL-STD-810, Method 510	Dust:300-1750 Ft/Min Sand:3540-5700 Ft/Min
5.1.2.5	Greenwater Loading	Not Applicable	----
5.1.2.6	Gun Muzzle	DoD-STD-1399 Sec 072, Part 2	Not Investigated
5.1.2.7	Humidity	IEC 68-2-30Db (25°C to 55°C) -or- MIL-STD-810, Method 507 IEC 68-2-3Ca (21 days)	Not Investigated 95% Non-Condensing
5.1.2.8	Hydrostatic Pressure	Not Applicable	----
5.1.2.9	Icing	Not Applcable	----
5.1.2.10	Missile Exhaust	DoD-STD-1399 Sec 072, Part 1	Not Investigated
5.1.2.11	Nuclear Hardening	NAVSEAINST C3401.1 NSWC TR 87-192 MIL-STD-462 (RS05&CS10)	Not Investigated
5.1.2.12	Salt Fog (Spray)	MIL-STD-810,Method 509 IEC 68-2-11Ka(48 hours)	Not Investigated
5.1.2.13	Ship Motion And Attitude	DoD-STD-1399, Sec 301 MIL-STD-2036, Appendix D	+/-45 Degrees For 30 Min Inclination of 15 Degrees
5.1.2.14	Shock	Grade A: MIL-S-901 MIL-STD-810, Method 516 Procedures I&IV(Functional) II,III,IV,&VIII--(Storage/Transport)	See Paragraphs 3.1.2.7 And 4.3.2
5.1.2.15	Solar Radiation	Not Applicable	----
5.1.2.16	Spray Tight Enclosures	MIL-STD-108	Not Investigated

Table 3 (continued)

PARAGRAPH	REQUIREMENT	MILITARIZED (Fully Hardened) SPEC/STD	MILITARIZED (Fully Hardened) REQUIRED VALUE
5.1.2.17	Temperature Ranges	MIL-STD-2036 (Controlled Environment) MIL-STD-810 -- Methods 501&502	Operating: 0°C to +50°C Shipping: -40°C to +70°C
5.1.2.18	Underwater Explosion	Not Applicable	----
5.1.2.19	Vibration	MIL-STD-167-1, Type 1	See Paragraph 3.1.2.9
5.1.2.20	Wind	Not Applicable	----

3.1.2 Minimum Acceptable Environmental Requirements for Shipboard Use

Minimum acceptable environmental requirements for components that are intended for shipboard use are summarized in Table 4. In Table 4, requirements that are not generally applicable and those that are not applicable due to the assumption that the VMEbus components under consideration would be installed in a sheltered, controlled environment are indicated as "Not Applicable". The remaining environmental requirements for minimal acceptance are addressed in the following paragraphs.

3.1.2.1 Altitude, Non-Operating

Draft MIL-STD-2036 (Navy) states, "Equipment with hermetic seals... shall be designed so that it will not be damaged when under transit in an un-pressurized cargo bay of an aircraft at 4.6 kilometers (15,000 feet). It is to the discretion of the program manager if the equipment is to be fully functional following an explosive decompression test. In general, the rate of altitude change shall not exceed 10 millisecond (2,000 feet/minute). Further guidance may be obtained from MIL-STD-810, Method 500. Altitude tests shall be in accordance with IEC 68-2-13 or MIL-STD-810, Method 500.".

Table 4 - Minimum Acceptable Shipboard Environmental Requirements

PARAGRAPH	REQUIREMENT	MIN. ACCEPTABLE SPEC/STD	MIN. ACCEPTABLE REQUIRED VALUE	COMMENT
5.1.2.1	Altitude NonOperating	MIL-STD-810, Method 500 -or- IEC 68-2-13	15,000 Ft. Unpressurized	-----
5.1.2.2	DC Magnetic Field Environment	DoD-STD-1399, SEC 070, Part 1	Normal: 1600 Amp/m (5 min)(Steady State Field) Special Conditions: 400 Amp/m (Residual Field)	Special Circumstances: Required if Equipment Operates Simultaneously with Degaussing System
5.1.2.3	Electromagnetic Susceptability	MIL-HDBK-235	See Paragraph 3.1.2.3	Application Dependent
5.1.2.4	Dust and Sand	Not Applicable	-----	-----
5.1.2.5	Greenwater Loading	Not Applicable	-----	-----
5.1.2.6	Gun Muzzle	Not Applicable	-----	-----
5.1.2.7	Humidity	ASHRAE Handbook	65%	Some Manufacturers Permit up to 80%
5.1.2.8	Hydrostatic Pressure	Not Applicable	-----	-----
5.1.2.9	Icing	Not Applicable	-----	-----
5.1.2.10	Missile Exhaust	Not Applicable	-----	-----
5.1.2.11	Nuclear Hardening	DoD Directive 4245.4 NSWC TR 90-22	See Paragraph 3.1.2.5	Application Dependent
5.1.2.12	Salt Fog (Spray)	Not Applicable	-----	-----
5.1.2.13	Ship Motion And Attitude	DoD-STD-1399, SEC 301	See Paragraph 3.1.2.6	-----
5.1.2.14	Shock	Grade B:MIL-S-901 Grade C:No Test	See Paragraph 3.1.2.7	-----
5.1.2.15	Solar Radiation	Not Applicable	-----	-----
5.1.2.16	Spray Tight Enclosures	Not Applicable	-----	-----
5.1.2.17	Temperature Ranges	MIL-STD-2036 (Controlled Environment) MIL-STD-810, Methods 501&502	Operating 0°C to +50°C Shipping -40°C to +70°C	-----
5.1.2.18	Underwater Explosion	Not Applicable	-----	-----
5.1.2.19	Vibration	MIL-STD-167-1, Type 1	See Paragraph 3.1.2.9	-----
5.1.2.20	Wind	Not Applicable	-----	-----

3.1.2.2 DC Magnetic Field Environment

Draft MIL-STD-2036 (Navy) states, "Equipment designated for installation on ships which contain degaussing or mine neutralization equipment shall have requirements which are tailored to meet DOD-STD-1399, Section 070.".

This requirement is considered to be a requirement that would be imposed under special circumstances. For this reason, it is not considered significant with respect to typical applications of the VMEbus components, and is not treated further in this study.

3.1.2.3 Electromagnetic Susceptibility

Draft MIL-STD-2036 (Navy) states, "Equipment shall be capable of operating in the presence of the expected conducted and radiated electromagnetic environment (EME) in accordance with MIL-HDBK-235.".

MIL-HDBK-235 states, in part, "...general design requirements and limits in existing electromagnetic compatibility (EMC) and interference (EMI) standards must be analyzed to determine their suitability and applicability for a given development and procurement. The standards are to be tailored by the Procuring Activity to the peculiarities of the specific equipment, its mission and operational concepts, the probabilities of achieving intra- and inter-system EMC program cost objectives and the anticipated operational electromagnetic environment. Definitive postulations of the total intended environment are required at various stages during the system design, as well as requirements to demonstrate operation and survivability in those environments.... This document provides information and guidance to the project manager, acquisition manager and others responsible for the design, test and procurement of electrical and electronic components, equipments, subsystems and systems on the representative maximum electromagnetic environment which may be encountered at various stages of their life cycle. The intent of this document is not to provide detailed electromagnetic environment specifications since each equipment and procurement is somewhat unique, but rather, to provide guidance and information which must be weighed during design and procurement. Use of this document will require engineering judgement...".

The purpose of MIL-HDBK-235 is to provide:

"(a) Information on the electromagnetic environment for consideration in the design and procurement of new systems, subsystems, and equipments which may be exposed to electromagnetic radiation environment levels during their life cycle.", and

"(b) Information for use in tailoring the radiated susceptibility requirement RS03 of MIL-STD-461 and the requirements of MIL-E-6051, and to supplement the requirements of MIL-STD-1385 and MIL-STD-1512 to ensure adequate consideration of the electromagnetic environment during equipment and system design."

MIL-HDBK-235, Part 1A, provides approximate electromagnetic environment levels for general information. Reference must be made to classified parts of MIL-HDBK-235 for more specific requirements. Table 5 gives the approximate electromagnetic environment levels from MIL-HDBK-235, Part 1A, for transport and shipboard conditions.

This requirement would be applied to a particular application dependent configuration of VMEbus components within a chassis. Due to the application dependent nature of this requirement, it is not treated further in this study.

3.1.2.4 Humidity

Draft MIL-STD-2036 (Navy) states, "Equipment shall be capable of operation in an environment conforming to the full range of requirements for data processing spaces of the ASHRAE Handbook, and specifically, the HVAC SYSTEMS AND APPLICATION VOLUME of the handbook.".

The ASHRAE Handbook, Chapter 33 on Data Processing System Areas, recommends a maximum relative humidity of 65% as the design condition for air supply directly to computer equipment, and notes that some manufacturers permit a relative humidity up to 80%.

3.1.2.5 Nuclear Hardening

Draft MIL-STD-2036 (Navy) states, "It is the responsibility of the specifier to determine if the equipment requires nuclear hardening, and the degree of nuclear hardening. DoD Directive 4245.4 provides further guidance. Installation in a sheltered, controlled environment does not protect the equipment from all effects of a nuclear event. ... With proper care, COTS equipment can be ruggedized to meet the nuclear environment. The specifier may consult NSWC TR 90-22 for the techniques to harden equipment to the nuclear environment.".

This requirement is considered to be application dependent, thus, is not a generally imposed environmental requirement. For this reason, it is not considered further in this study.

Table 5 - Approximate EM Environment Levels

LOCATION	FREQ. RANGE (MHz)	APPROX. NEAR FIELD EM LEVELS POWER DENSITY (mW/cm2) PEAK	AVG	APPROX. NEAR FIELD EM LEVELS FIELD STRENGTH (V/m) PEAK	AVG
Factory to Depot	< 35	-----	-----	-----	10
	35 - 2000	-----	-----	-----	5
	> 2000	-----	-----	-----	20
Depot to Checkout	< 35	-----	-----	-----	10
	35 - 2000	-----	-----	-----	5
	> 2000	-----	-----	-----	20
Checkout Area Aboard Ship	< 30	-----	-----	1	1
	30 - 2000	-----	-----	32	1
	> 2000	-----	-----	1	1
Hangar Deck (CVs and CVNs)	< 30	-----	-----	32	10
	30 - 2000	-----	-----	50	5
	> 2000	-----	-----	334	10
Flight Deck of Aircraft Carriers (CVs and CVNs)	< 30	-----	-----	200	100
	30 - 2000	-----	-----	5100	183
	> 2000	-----	-----	9700	183
Weather Decks, Missile Launching Ships (CG,CGN,FFG,&FFs)	< 30	-----	-----	200	100
	30 - 2000	-----	-----	5100	183
	> 2000	-----	-----	9700	183
Weather Decks, Non-Missile Combat Ships	< 30	-----	-----	200	100
	30 - 2000	-----	-----	5100	183
	> 2000	-----	-----	7220	183
Envelope of Maximum EM Environment Levels in Main Beam of US Shipboard Emitters	< 30	0.11	0.11	20	20
	30 - 2000	2000	60	4120	460
	> 2000	125000	410	31,000	300
Maximum EM Environment Levels for Hostile Shipboard Emitters	< 30	0.4	0.4	40	40
	30 - 2000	14500	90	7300	600
	> 2000	250000	450	30,000	1400
Actual Hostile Jammers	< 2000	25	2	300	85
	> 2000	35	30	360	320
Postulated Hostile Jammers	< 2000	4500	25	4100	300
	> 2000	35000	350	12000	1200

3.1.2.6 Ship Motion and Attitude

Draft MIL-STD-2036 (Navy) states, "Ships motion and attitude conditions are defined in DoD-STD-1399, Section 301. Under heavy weather conditions, office equipment such as duplicating machines may be permitted to shut down when the inclination exceeds a pre-defined limit.".

DoD-STD-1399, Section 301, establishes interface requirements for ship systems and equipment that are affected by ship motion. Information necessary for the use of DoD-STD-1399, Section 301, includes required operational capabilities versus sea state, ship size, and location and weight of the equipment. The purpose of DoD-STD-1399, Section 301, is to provide a standard method for calculation of static and dynamic forces that may be generated by the motion and attitude of the ship.

This requirement does not appear to be applicable to solid state printed circuit boards as individual components, and it appears to be a design, not environmental, requirement when the boards are placed in an enclosure; i.e., the boards must be secured in a manner that will prevent them from moving due to ship motion. For these reasons, this requirement is not treated further in this study.

3.1.2.7 Shock

Draft MIL-STD-2036 (Navy) states, "Equipment which is normally stowed for combat shall be classified as grade C with no testing requirements. All other equipment shall be classified as grade B and be tested in accordance with MIL-S-901. Note: MIL-S-901 does not specify grade C.". The grade C shock environment is defined in DoD-STD-1399, Section 072, Part 4.

MIL-S-901 categorizes tests according to the weight of the equipment to be tested. The VMEbus components would fall into the lightweight (less than 550 pounds) test category. It is assumed that the VMEbus equipment would be classified as Class II, which is defined as equipment that will meet the requirements of MIL-S-901 with the use of resilient mountings installed between the equipment and the ship structure or shipboard foundation. It is further assumed that a VMEbus principal unit would comprise a chassis, power supply, and a combination of various types of printed circuit boards.

The lightweight shock test specified by MIL-S-901 consists of three blows with a 400 pound hammer at hammer heights of 1, 3, and 5 feet applied to each of the three mutually perpendicular axes of the item being tested (i.e., top, back, and side). The shock test acceptance criteria for Grade B items are that the equipment shall withstand the shock tests without creating a hazard to personnel or to Grade A equipment, and:

(a) the tested item, portions thereof, or the contents thereof shall not come adrift due to exposure to shock;

(b) injurious, flammable, radioactive, acidic, caustic, or otherwise hazardous liquids, solids, or gases shall not be released as a result of exposure of the tested item to shock; and,

(c) tested items shall not demonstrate a potential for fire hazards.
MIL-S-901 states that, "It is not required that Grade B items be operable after shock testing.".

3.1.2.8 Temperature Ranges

Draft MIL-STD-2036 (Navy) states, "Equipment temperature requirements for shipping and operating shall be tailored from Table IV. Equipment shall not be damaged when ambient conditions are outside nominal operating limits.". For a controlled environment, the required operating temperature range is +0° to +50°C and the required shipping temperature range is -40°C to +70°C.

3.1.2.9 Vibration

Draft MIL-STD-2036 (Navy) states, "Shipboard equipment shall be in accordance with the type I vibration requirements of MIL-STD-167-1".

MIL-STD-167-1 specifies a series of tests to be conducted separately in each of the three principal directions of vibration. All tests in one direction are to be completed before proceeding to tests in another direction. The equipment is to be energized to perform its normal functions during the vibration tests. The series of tests consists of an exploratory vibration test, a variable frequency test, and an endurance test.

The exploratory vibration test is performed to determine the presence of resonances in the equipment. The equipment shall be secured to the vibration table and vibrated at frequencies from 4 Hz (or lowest attainable frequency) to 33 Hz, at a table vibratory single amplitude of 0.010 $\pm$ 0.002 inch. For frequencies from 34 to 50 Hz, a table amplitude of 0.003 plus zero, minus 0.001 inch shall be used. The changes in frequency shall be made in discrete frequency intervals of 1 Hz and maintained at each frequency for about 15 seconds. The frequencies and locations at which resonances occur shall be noted.

For the variable frequency test, the equipment shall be vibrated from 4 Hz (or lowest attainable frequency) to 50 Hz in discrete frequency intervals of 1 Hz at the amplitudes shown in Table 6. At each integral frequency, the vibration shall be maintained for 5 minutes.

Table 6 - Vibratory Displacement of Environmental Vibration

FREQUENCY RANGE (Hz)	TABLE AMPLITUDE (Hz)
4 to 15	0.030 $\pm$ 0.006
16 to 25	0.020 $\pm$ 0.004
26 to 33	0.010 $\pm$ 0.002
34 to 40	0.005 $\pm$ 0.001
41 to 50	0.003 + 0.000 - 0.001

For the endurance test, the equipment shall be vibrated for a total period of at least two hours at the resonant frequencies chosen by the test engineer. If no resonance is observed, this test shall be performed at 50 Hz or at the upper frequency calculated for the specific ship class. The amplitudes of vibration shall be in accordance with Table 6 and Figure 1 of MIL-STD-167-1.

3.1.3 Operational Constraints

Draft MIL-STD-2036 (Navy) includes a number of additional requirements under the heading "operational constraints". These requirements are sometimes considered environmental requirements, and apply to both fully hardened and minimum acceptable equipments. For purposes of this study, the requirements designated as operational constraints are summarized in Table 7, but are not treated further.

3.1.4 Recommended Target Minimum Acceptable Environmental Requirements

Upon consideration of the minimum acceptable environmental requirements for components that are intended for shipboard use, the most significant and most easily assessable requirements are:

(a) Altitude
(b) Humidity
(c) Shock
(d) Temperature
(e) Vibration

This subset of environmental requirements appears to represent a reasonable compromise between excessive cost to ruggedize equipment for extreme environments and insufficient ruggedization for shipboard use, and is considered to be a reasonable target for the Navy Standard Backplane.

Table 7 - Operational Constraints

PARAGRAPH	REQUIREMENT	FULLY HARDENED AND MINIMUM ACCEPTABLE SPEC/STD	FULLY HARDENED AND MINIMUM ACCEPTABLE REQUIRED	COMMENT
5.1.3.1	Airborne Noise	MIL-STD-740-1	Dependent Upon Equipment Grade	-----
5.1.3.2	Stuctureborne Noise	MIL-STD-740-2, Type III	Not Investigated	----
5.1.3.3	Alternating Current (AC) Power	MIL-STD-1399, SEC 300, Type 1	Not Investigated	----
5.1.3.4	Submarine Direct Current (DC) Power	Not Applicable	-----	-----
5.1.3.5	Electromagnetic Emissions	MIL-STD-461(Requirements) MIL-STD-462(Tests) NTIA Manual	CE01 CE03 RE01 RE02	Note: COTS may be procured to FCC Regulations and modified using EMI Filters and sheilding
5.1.3.6	EMCON Requirements	MIL-STD-1633	Not Investigated	----
5.1.3.7	DC Magnetic Requirements for Mine-sweeper Equipment	DoD-STD-2143 MIL-I-17214(Tests)	Not Investigated	-----
5.1.3.8	Fungus	MIL-STD-810,Method 508	28 days in test chamber with Fungi Culture	-----
5.1.3.9	Toxic Hazards	ACGIH Publication IBSN 0-936-712-39-2	Not Investigated	----
5.1.3.10	Prohibited Materials	MIL-STD-2036,Table V NAVSUPINST 5100.27 29CFR 1910.1001 to 1910.1101	Not Investigated	----
5.1.3.11	Safety	MIL-STD-2036,Table V MIL-STD-454,Requirement 1 UL-478	Not Investigated	-----

4.0 COMPARISON OF ENVIRONMENTAL REQUIREMENTS TO VMEBUS COMPONENT CAPABILITIES

The data in the 420 records of the dBASE III database was examined relative to the environmental requirements for altitude. humidity, shock, temperature, and vibration in order to determine whether the VMEbus components meet the required conditions, to appraise the requirements with respect to the manufacturer's ability to meet the requirement, and to characterize the efforts needed to upgrade VMEbus components for Navy Standard Backplane use. The dBASE III report generation facility was used to produce the reports identified in this section.

4.1 Altitude Characteristics

Of the 420 records in the dBASE III database, 74 were found in which the vendor had reported that the component met some form of altitude test. It should also be noted that only nine vendors provided this information. Appendix A-3 provides a summary of the reported altitude characteristics.

Table 8 summarizes the number of components meeting an altitude requirement versus altitude. Only three of the 74 components do not meet the 15,000 ft. altitude requirement of draft MIL-STD-2036 (Navy).

It is noted that MIL-E-5400, General Specification for Aerospace Electronic Equipment, defines seven equipment classes that are related to altitude and temperature range. Table 9 lists these equipment classes and shows their definition. From the values in Tables 8 and 9, it appears that many of the components identified in the database are designed for implementation in airborne applications. Such components could readily be used in shipboard applications.

Based upon this sample, it is considered that the draft MIL-STD-2036 (Navy) requirement for transit in an unpressurized cargo bay of an aircraft at 15,000 feet is appropriate for equipment that will be used in a shipboard application.

Table 8 - Altitude Characteristics

ALTITUDE (Feet)	NUMBER OF COMPONENTS
70,000	30
50,000	27
40,000	2
35,000	1
18,000	5
15,000	6
12,000	1
10,000	2

Table 9 - MIL-E-5400 Electronic Equipment Classes

CLASS	ALTITUDE (Feet)	OPERATING TEMP RANGE	INTERMITTENT TEMP
1	50,000	-54°C to +55°C	+71°C
1A	30,000	-54°C to +55°C	+71°C
1B	15,000	-40°C to +55°C	+71°C
2	70,000	-54°C to +71°C	+95°C
3	100,000	-54°C to +95°C	+125°C
4	100,000	-54°C to +125°C	+150°C
5	100,000 (<6 hrs.)	-54°C to +95°C	+125°C

4.2 Temperature and Humidity Characteristics

Of the 420 records in the dBASE III database, 142 were found in which the vendor had reported operating temperature, storage temperature, humidity, or some combination of these characteristics. Eighteen vendors provided this information. Appendix A-4 provides a summary of the reported temperature and humidity characteristics of VMEbus components.

4.2.1 Operating Temperature

Table 10 summarizes the number of components for which the vendor had reported the operating temperature range. All but one of the components listed in the database meet the draft MIL-STD-2036 (Navy) requirement for an operating temperature range of 0°C to +50°C.

4.2.2 Storage Temperature

The storage temperature range was reported for 104 VMEbus components. Table 11 summarizes the number of components for which the vendor had reported the storage temperature range. Seven of the components listed in the database for which the storage temperature was reported do not meet the draft MIL-STD-2036 (Navy) requirements for a storage temperature range of -40°C to +70°C.

Table 10 - Operating Temperature Range

OPERATING TEMPERATURE RANGE	NUMBER OF COMPONENTS
-55°C to +125°C	2
-55°C to +85°C	39
-55°C to +75°C	1
-55°C to +71°C	6
-54°C to +71°C	5
-54°C to +55°C	1
-40°C to +85°C	63
-25°C to +85°C	9
-25°C to +65°C	1
-20°C to +75°C	1
-20°C to +65°C	3
-10°C to +55°C	1
0°C to +70°C	3
0°C to +65°C	4
0°C to +60°C	1
0°C to +50°C	1
+10°C to +38°C	1

Table 11 - Storage Temperature Range

STORAGE TEMPERATURE RANGE	NUMBER OF COMPONENTS
-65°C to +165°C	2
-65°C to +150°C	6
-65°C to +125°C	10
-62°C to +150°C	4
-62°C to +125°C	14
-62°C to +105°C	2
-62°C to +85°C	1
-62°C to +71°C	5
-57°C to +125°C	1
-55°C to +150°C	1
-55°C to +125°C	2
-55°C to +100°C	31
-55°C to +85°C	1
-55°C to +71°C	1
-50°C to +100°C	12
-45°C to +85°C	1
-40°C to +85°C	3
-33°C to +71°C	6
-25°C to +85°C	1

4.2.3 Humidity

Humidity conditions were reported for 117 VMEbus components. Table 12 summarizes the number of components for which the vendor reports the humidity conditions. All of the components listed in the database for which the humidity conditions were reported met the requirements of draft MIL-STD-2036 (Navy) for minimum acceptability for shipboard use.

Table 12 - Humidity Conditions

HUMIDITY		NUMBER OF COMPONENTS
0 to 100%	Condensing	8
0 to 95%	Non-Condensing	68
0 to 95%		28
0 to 90%	Non-Condensing	2
0 to 90%		1
5 to 95%	Non-Condensing	8
5 to 90%	Non-Condensing	1
10 to 85%	Non-Condensing	1

4.2.4 Appraisal of Temperature and Humidity Requirements

Based upon the sample of VMEbus components for which temperature and humidity conditions are reported, it is considered that the draft MIL-STD-2036 (Navy) requirements for operating temperature, storage temperature, and humidity are appropriate for equipment that is intended for use in a controlled, sheltered shipboard application.

4.3 Shock

The dBASE III database records contain information on shock characteristics as reported by the vendors. Only one vendor claims compliance with MIL-S-901. All other vendors state shock characteristics in terms of the requirements of MIL-E-5400 or MIL-STD-810, Method 516. The requirements of these documents are stated in the following paragraphs.

4.3.1 MIL-E-5400 Shock Requirements

MIL-E-5400 states, "Equipment (with vibration isolators in place, if any) shall not suffer damage or subsequently fail to provide the performance specified in the detail equipment specification when subjected to 18 impact shocks of 15 g, consisting of 3 shocks in opposite directions along each 3 mutually perpendicular axes, each shock impulse having a time duration of 11 $\pm$ 1 milliseconds.". MIL-E-5400 also states, with respect to bench handling, that, " The equipment shall withstand the shock environment encountered during servicing.".

4.3.2 MIL-STD-810, Method 516 Shock Requirements

MIL-STD-810, Method 516 offers nine separate procedures for conduct of shock tests, depending upon the shock environment. These procedures, listed below, are described in the following paragraphs:

(a) Functional shock (Procedure I)
(b) Equipment to be packaged (Procedure II)
(c) Fragility (Procedure III)
(d) Transit drop (Procedure IV)
(e) Crash hazard (Procedure V)
(f) Bench handling (Procedure VI)
(g) Pyrotechnic Shock (Procedure VII)
(h) Rail impact (Procedure VIII)
(i) Catapult launch/arrested landing (Procedure IX)

4.3.2.1 Functional Shock

Procedure I, functional shock, is intended to test equipment assemblies in their functional mode. This procedure requires that the equipment undergoing test be subjected to a sufficient number of shocks to meet the specified test conditions at least three times in both directions along each of three orthogonal axes. The equipment is required to be operational before, during, and after testing, as appropriate to its functional use. The test transient specified for flight equipment is 20 g for an effective transient duration of 6 to 9 milliseconds. The test transient specified for ground equipment is 40 g for an effective transient duration of 6 to 9 milliseconds. No test transient is specified for shipboard equipment.

4.3.2.2 Equipment to be Packaged

Procedure II is to be used when equipment will require a shipping container. It establishes a minimum critical acceleration level for a handling drop height. The test is conducted with the test item unpackaged and in a non-operational mode. The test item is subjected to a series of trapezoidal 30 g shock pulses. Duration of the pulse is calculated, based upon the item's weight.

4.3.2.3 Fragility

Procedure III is used to determine an item's fragility level so that packaging can be designed for it, or so the item can be redesigned to suit packaging requirements. A design drop height (i.e., the height from which the test item might be dropped in its shipping configuration and be expected to survive) is selected based upon the item's weight. The maximum product velocity change and pulse duration are calculated, and the item is subjected to shock pulses, increasing the maximum acceleration level incrementally until damage to the test item occurs. This will be established as the test item's critical acceleration fragility level.

4.3.2.4 Transit Drop

Procedure IV is intended for equipment in its transit or combination case as prepared for field use (carried to a combat situation by man, truck, rail, etc.). It is used to determine if the test item is capable of withstanding the shocks normally induced by loading and unloading of equipment. For this test, the test item is to be in the same configuration as it would be carried into a combat situation. Items that weigh less than 100 pounds are dropped from a height of either 48 or 30 inches (depending upon the item's largest dimension) a total of 26 times (i.e., each face, edge, and corner).

4.3.2.5 Crash Hazard

Procedure V is for equipment mounted in an air or ground vehicle that could break loose from its mounts and present a hazard to vehicle occupants. This procedure is not applicable to shipboard equipment.

4.3.2.6 Bench Handling

Procedure VI should be used for equipment that may experience bench or bench-type maintenance. It is used to determine the ability of the test item to withstand the usual level of shock encountered during typical bench maintenance or repair. For this test, one edge of the item is raised four inches above the bench top or until the chassis forms a 45 degree angle with the bench top or until the point of balance is reached, whichever is less. The item is then released. This test is repeated for a total of four drops on each face which the test item could be placed practically during servicing.

4.3.2.7 Pyrotechnic Shock

Procedure VII is intended for equipment to be subjected to shock from explosive devices. This procedure is not applicable to shipboard equipment.

4.3.2.8 Rail Impact

Procedure VIII is for equipment that will be transported by rail. It is intended to determine the effect of normal railroad car impacts that occur during rail shipment. For this test, the test item is secured to prevent any longitudinal, vertical or lateral movement at one end of a railroad car. The rail car then undergoes a series of impacts at eight, nine, or ten miles per hour. The test item should not show any signs of physical degradation and should be capable of full operation following the test.

4.3.2.9 Catapult Launch/Arrested Landing

Procedure IX is intended for equipment mounted in or on fixed-wing aircraft that are subjected to catapult launches and arrested landings. This procedure is not applicable to shipboard equipment.

4.3.3 Shock Characteristics

Shock characteristics were reported by eleven vendors on 109 VMEbus components listed in the dBASE III database. Appendix A-5 provides a summary of the reported shock characteristics. Table 13 summarizes the number of components for which the vendor had reported the shock characteristics for each level of shock. Assuming that the MIL-E-5400 shock level is equivalent to the MIL-S-901 test for Grade B equipment, all of the components for which the vendors reported shock characteristics meet the shock requirements of draft MIL-STD-2036 (Navy).

Table 13 - Shock Characteristics

SHOCK LEVEL	NUMBER OF COMPONENTS
MIL-S-901	1
50 g for 11 ms	5
40 g for 11 ms	12
30 g for 11 ms	26
25 g for 11 ms	3
20 g for 11 ms	14
15 g for 11 ms	12
30 g for 6-9 ms	5
20 g for 6 ms	31

4.3.4 Appraisal of Shock Requirements

The traditional shock test described in MIL-S-901 is considered appropriate for the VMEbus chassis, and may be appropriate to test individual components when they reside within the chassis, but the MIL-S-901 test is not considered appropriate for individual VMEbus components such as printed circuit cards and power supplies that could be treated as separate test items. For these components, it is suggested that the tests described in MIL-E-5400 and MIL-STD-810, Method 516 are more appropriate.

A minimum acceptance shock test series for shipboard equipment might consist of a non-operational test similar to that described in MIL-E-5400 or MIL-STD-810, Method 516, Procedure I (Procedure I does not currently specify a test transient for shipboard equipment); a transit drop test in accordance with MIL-STD-810, Method 516, Procedure

IV; and, a bench handling test in accordance with MIL-STD-810, Method 516, Procedure VI.

4.4 Vibration

The dBASE III database records contain information on vibration characteristics as reported by the vendors. Only one vendor claims compliance with MIL-STD-167-1. All other vendors state vibration characteristics in terms of the requirements of MIL-E-5400, MIL-E-16400, and MIL-STD-810, Method 514. The requirements of these documents are stated in the following paragraphs.

4.4.1 MIL-E-5400 Vibration Requirements

MIL-E-5400 states,"When normally mounted (with vibration isolators in place, if any), the equipment shall not suffer damage or fail to meet specified performance when subjected to the applicable vibration environment detailed herein or as specified in the detail equipment specification or contract. Selection of the applicable vibration environment (type of excitation, frequency range, and amplitude as a function of aircraft and application location) shall be determined using the following criteria:"

(a) Equipment designed for installation in propeller aircraft "shall withstand sinusoidal excitation over the frequency range of 5 to 500 Hz with amplitude specified by the appropriate curve of Figure 2" of MIL-E-5400. The appropriate curve is defined by application location. Acceleration levels vary from 2 g to 20 g for a double amplitude displacement of up to 0.036 inch, and from 1 g to 2 g for a double amplitude displacement of up to 0.10 inch.

(b) Equipment designed for installation in jet aircraft "shall withstand either random, sinusoidal, or, in particular applications, both random and sinusoidal excitation as indicated below."

(1) For random excitation, "the vibration spectrum shall extend from 15 to 2000 Hz with the amplitude specified in the detail equipment specification or contract. Where actual measured data is not available to establish random requirements, the mathematical formulae contained in MIL-STD-810 may be used to calculate applicable amplitudes when specifically permitted by the detail equipment specification or contract."

(2) For sinusoidal excitation, "sinusoidal vibration covering the frequency range of 5 to 2000 Hz with the amplitude specified by the appropriate curve of Figure 2" [of MIL-E-5400]" shall be used when random vibration requirements are not specified in the detail

equipment specification or contract." Acceleration levels vary from 1 g to 20 g.

(3) For random and sinusoidal excitation, "in particular applications, both random and sinusoidal excitations may be required to simulate the in-service use of the equipment. The detail equipment specification or contract will specify such requirements."

(c) Equipment designed for installation in helicopters "shall withstand sinusoidal excitation over frequency range of 5 to 2000 Hz with the amplitude specified by Curve III of Figure 2" of MIL-E-5400. Acceleration levels vary from 2 g to 5 g.

4.4.2 MIL-STD-810, Method 514 Vibration Requirements

MIL-STD-810, Method 514 divides vibration environments into twelve categories, three of which are transportation induced and nine of which are application induced. Procedure I of Method 514 is used for testing an item in nine of the twelve categories, including environmental categories of basic transportation, propeller aircraft, jet aircraft, helicopter, and marine (shipboard).

For the shipboard vibration environment, MIL-STD-810, Method 514 states, "The random vibration test of shipboard equipment should follow either the Basic Transportation Test" [of MIL-STD-810, Method 514] "or the Bench Handling Shock Test" of MIL-STD-810, Method 516, Procedure VI. If MIL-STD-810, Method 514 is used, the random vibration spectrum for shipboard installations covers a frequency range of 1 to 50 Hz, with a Power Spectral Density (PSD) of 0.001 g^2/Hz.

MIL-STD-810, Method 514 also states, "In order to verify structural integrity and the compatibility of equipment/mounting resonance frequencies with shipboard input frequencies, a sinusoidal vibration test should be conducted in accordance with MIL-STD-167-1 for Type I (Environmental Vibration).".

4.4.3 MIL-STD-16400 Vibration Requirements

MIL-STD-16400 states, "Shipboard equipment shall conform to the type I vibration requirements of MIL-STD-167-1.". MIL-STD-167-1 requirements were summarized in 3.1.2.9 above.

4.4.4 Vibration Characteristics

Vibration characteristics were reported by twelve vendors on 113 VMEbus components listed in the dBASE III database. Appendix A-6 provides a summary of the reported vibration characteristics. (Please note that values for sinusoidal and random

vibration in Appendix A-6 and in the database records do not always appear in the proper field.) Table 14 summarizes the number of components for which the vendor reported the vibration characteristics for each level of vibration (Note: some vendors have reported both sinusoidal and random vibration characteristics for their components).

Because most vendors have reported vibration characteristics in terms of the requirements of MIL-E-5400 and MIL-STD-810, Method 514, it cannot be stated with certainty whether the components meet the requirements of draft MIL-STD-2036 (Navy), but it appears that the components for which vibration characteristics are reported could satisfy the requirements of MIL-STD-167-1 and thus draft MIL-STD-2036 (Navy).

Table 14 - Vibration Characteristics

VIBRATION LEVEL	NUMBER OF COMPONENTS
10 g at 5 to 2000 Hz	20
10 g at 4 to 33 Hz	1
7.6 g at 20 to 2000 Hz	12
4.5 g at 5 to 2000 Hz	1
4.2 g at 5 to 500 Hz	12
4 g at 5 to 2000 Hz	5
4 g at 15 to 2000 Hz	1
2 g at 5 to 500 Hz	44
2 g at 5 to 55 Hz	5
0.3 g at 5 to 100 Hz	1
0.15 g^2/Hz at 15 to 2000 Hz	3
0.10 g^2/Hz at 15 to 2000 Hz	26
0.05 g^2/Hz at 10 to 2000 Hz	5
MIL-E-16400/MIL-E-5400	2
MIL-E-16400	2
MIL-STD-167-1	1

4.4.5 Appraisal of Vibration Requirements

The vibration tests described in MIL-STD-167-1 are considered appropriate for testing of VMEbus components that are intended for use in a controlled, sheltered shipboard application.

Since several manufacturers apparently test and report vibration characteristics of their components in terms that are referenced to MIL-E-5400, it is recommended that similar requirements be specifically stated in draft MIL-STD-2036 (Navy) in order to provide a more direct correlation between the vibration requirements for aircraft oriented and shipboard oriented components. For example, a component that has been tested for aircraft use and reports a vibration level of 0.05 g^2/Hz over a frequency range of 10 to 2000 Hz may not require further testing to meet a shipboard requirement of

0.001 g^2/Hz over a frequrency range of 1 to 50 Hz. Without a precise statement of requirements in the same units, it is difficult to ascertain whether one requirement is a subset of the other.

It is also recommended that further investigation be conducted with regard to possible substitution of the MIL-STD-810, Method 516, Procedure VI shock test in lieu of the vibration test for minimum acceptability for shipboard use.

5.0 IEEE P1156.1 ENVIRONMENTAL SPECIFICATIONS

Independent of U.S. Navy efforts to define design and environmental specifications for shipboard electronic equipment, the Institute of Electrical and Electronics Engineers (IEEE) is in the process of developing a standard for core environmental conditions for computers. This standard, P1156.1, Environmental Core Specifications and Resources (draft 3.0 dated 7 June 1991) is intended to provide design engineers and system engineers with requirements for core environmental conditions that all components and modules used in computers should be able to withstand. These include, but are not limited to, thermal, atmospheric, shock, vibration, and corrosion during storage and operation. The full text of draft 3.0 of IEEE P1156.1 is provided as Appendix C.

5.1 IEEE P1156.1 Environmental Performance Levels

Draft 3.0 of IEEE P1156.1 defines five environmental performance levels. These are:

(a) Level 1.

Environment primarily intended for aircraft, unsheltered marine (surface ship), and unsheltered shore applications subject to extreme vibration, shock, and temperature variations.

(b) Level 2.

Environment primarily intended for sheltered marine and sheltered shore applications subject to harsh vibration, shock, and temperature variations.

(c) Level 3.

Environment primarily intended for sheltered applications subject to moderate vibration, shock, and temperature variations.

(d) Level 4.

Environment primarily intended for thermally controlled, sheltered applications subject to moderate vibration and shock.

(e) Level 5.

Environment primarily intended for controlled sheltered applications subject to minimal vibration, shock, or temperature variations.

Qualification to one performance level also qualifies the component to all less demanding levels, except for the shock test magnitudes for levels 1 and 2.

5.2 Climatic Categories

Draft 3.0 of IEEE P1156.1 defines three climatic categories that represent the low and high storage temperature to which the component will be subjected. Table 15 summarizes the climatic categories and their related environmental performance levels.

Table 15 - Climatic Categories

TEMPERATURE RANGE	PERFORMANCE LEVEL				
	1	2	3	4	5
-55°C to +125°C	x	x			
-40°C to +65°C			x	x	
-40°C to +55°C					x

5.3 Environmental Conditions

Draft 3.0 of IEEE P1156.1 requires that computer modules/circuit cards and components withstand, without damage, the nonoperating/storage environmental core conditions listed in Table 16. Table 17 summarizes the IEEE P1156.1 environmental requirements that computer modules/circuit cards and components shall withstand while maintaining normal operation.

5.4 Status of IEEE P1156.1

IEEE P1156.1 is in a working draft status, but is considered reasonable complete. Current projections are that it will be distributed within IEEE for sponsor ballot following the October 1991 meeting of the IEEE P1156.1 Environmental Working Group, and, assuming that no major revisions are required, should be approved at the April 1992 meeting for publication and general distribution.

Table 16 - IEEE 1156.1 Non-Operating Environmental Requirements

Test	IEC PUB	Conditions	Environmtl. Performance Level 1	Environmtl. Performance Level 2	Environmtl. Performance Level 3	Environmtl. Performance Level 4	Environmtl. Performance Level 5
Low Temp. High Temp.	68-2-1-Ad 68-2-2-Bd	72 hr. duration	-55°C to +125°C	-55°C to +125°C	-40°C to +65°C	-40°C to +65°C	-40°C to +55°C
Thermal Shock	68-2-14-Na	3 hr.@ low temp. <3 min. transition time to high temp. Repeat for 5 cycles	-55°C to +125°C	-55°C to +85°C	-40°C to +70°C	-40°C to +70°C	-40°C to +70°C
Humidity	68-2-30-Db	6 cycles	+25°C to +55°C 95% RH	+25°C to +55°C 95% RH	+25°C to +55°C 93% RH	+25°C to +55°C 93% RH	+25°C to +55°C 93% RH
Shock	68-2-27-Ea	6 ms half sine wave pulse 3 pulses, both directions, 3 axes total of 18 pulses	100 g	100 g	30 g	30 g	15 g
Corrosion	68-2-11-Ka	48 hr. duration	X	X	X	----------	----------
Fungus	68-2-10-J	28 day duration	X	X	X	----------	----------
Flammability	695-2-2	Flame Application depends on volume flames self extinguish in <30 Sec Oxygen index > = 28%	 X	X X	X X	X X	X ----------
ESD	801-2	30 kV/150pF on exposed surfaces	X	X	X	X	X

Table 17 - IEEE 1156.1 Operating Environmental Requirements

Test	IEC PUB	Conditions	Environmtl. Performance Level 1	Environmtl. Performance Level 2	Environmtl. Performance Level 3	Environmtl. Performance Level 4	Environmtl. Performance Level 5
Low Temp. High Temp.	68-2-1-Ad 68-2-2-Bd	16 hr. duration	-55°C to +95°C	-10°C to +70°C	+5°C to +55°C	+5°C to +55°C	+5°C to +55°C
Sinusoidal Vibration	68-2-6-Fc	10-55 Hz,20 sweeps 55-2000Hz,2 sweeps 5-100 Hz,1 sweeps	1.5 mm/10 g 1.5 mm/10 g ------------	1.5 mm/10 g 1.5 mm/10 g ------------	------------ ------------ 0.35 mm/5 g	------------ ------------ 0.35 mm/5 g	------------ ------------ ------------
Random Vibration	68-2-36-Fdb	20-2000 Hz 30 min on each of 3 axes	0.2 g^2/Hz	0.1 g^2/Hz	------------	------------	------------
Shock	68-2-27	Half Sine wave pulse 3 pulses, both directions, 3 axes total of 18 pulses	30 g/6ms	50 g/11 ms	15 g/11 ms	15 g/11 ms	------------
Low Air Press	68-2-13	16 hr. duration	1050/ 40mbar	1050/ 550 mbar	1050/ 550 mbar	1050/ 700 mbar	1050/ 700 mbar
Radiation	MIL-M-28787	Optional	------------	------------	------------	------------	------------
ESD	801-2	15 kV/150 pF on exposed surfaces 15 kV/15 pF on exposed surfaces 25 kV/500 pF on exposed surfaces	X ------------ X	X ------------ X	X ------------ ------------	X X ------------	X ------------ ------------
EMI	FCC. Pt 1,Sub J	Meet FCC Requirements	X	X	X	X	X

6.0 AREAS FOR FURTHER EFFORT

6.1 Minimal Acceptance Ship Motion and Attribute Requirement

Draft MIL-STD-2036 (Navy) makes two statements regarding ship motion and attitude but imposes no requirement. It is recommended that the following be added to paragraph 5.1.2.13.2: "Inclination tests shall be conducted with the test item in an operational configuration and as specified in Appendix D.".

With respect to VMEbus components, this requirement would apply when the components are in an operational configuration (i.e., printed circuit boards and power supplies mounted in a chassis) in order to verify that the components are secured in a manner that will prevent them from moving or being thrown adrift due to ship motion.

6.2 Minimal Acceptance Shock Requirement

The MIL-S-901 shock test currently specified in draft MIL-STD-2036 (Navy) is a destructive test to determine whether the item under test might pose a hazard to personnel or equipment when subjected to the shipboard shock environment.

With regard to VMEbus components, this test is considered appropriate for the VMEbus chassis, and may be appropriate when the components are in an operational configuration, but it is not considered an appropriate test for individual components as separate test items.

It is recommended that a series of three shock tests be defined based upon the requirements stated in MIL-E-5400 and MIL-STD-810, Method 516. The series of tests might consist of the following:

(a) A test similar to that described in MIL-E-5400 or MIL-STD-810, Method 516, Procedure I, except that the test item shall be operational before and after, but not during the test.

(b) A transit drop test in accordance with MIL-STD-810, Method 516, Procedure IV.

(c) A bench handling test in accordance with MIL-STD-810, Method 516, Procedure VI.

It is noted that Procedure I does not specify a test transient for shipboard equipment. It is suggested that a transient of 15g for 11 milliseconds might be an appropriate value.

Further, it is noted that it may be possible to use Procedure VI in lieu of vibration tests, according to MIL-STD-810, Method 514, Category 9-Shipboard Vibration Test Levels.

6.3 Minimal Acceptance Vibration Requirement

Draft MIL-STD-2036 (Navy) specifies vibration testing in accordance with MIL-STD-167 for Type I equipment for minimal acceptance for shipboard application. This requirement is considered appropriate in order to verify structural integrity and the compatibility of equipment/mounting resonance frequencies with shipboard input frequencies.

It is recommended that draft MIL-STD-2036 (Navy) specifically state vibration level requirements (e.g., 15 g at 5 to 500 Hz and 0.001 g^2/Hz at 1 to 50 Hz) in the same units that are used in MIL-E-5400. This will provide a more direct correlation between the vibration requirements and characteristics for aircraft oriented and shipboard oriented components. Several vendors now report vibration characteristics in terms that are referenced to MIL-E-5400.

It is also recommended that further investigation be conducted with regard to possible substitution of the MIL-STD-810, Method 516, Procedure VI shock test in lieu of the vibration test for minimum acceptability for shipboard use.

6.4 Consideration of IEEE P1156.1

The IEEE P1156.1 standard on Environmental Core Specifications and Resources may offer a convenient means to establish minimal acceptable environmental requirements for standard backplane components. The standard is designed for use in conjunction with other documents, including IEEE 1014 (VMEbus) and IEEE 896.2 (Futurebus+).

Based upon a preliminary review of the environmental requirements stated in IEEE P1156.1 (IEC Test Procedures were not reviewed), it appears that the IEEE P1156.1, Environmental Performance Level 4 requirements are reasonably close to the minimal acceptable requirements of draft MIL-STD-2036 (Navy). Alternatively the Environmental Performance Level 3 requirements may be considered.

It is recommended that the development and status of IEEE P1156.1 be closely monitored, and that consideration be given to incorporating the requirements of IEEE P1156.1 into draft MIL-STD-2036 (Navy).